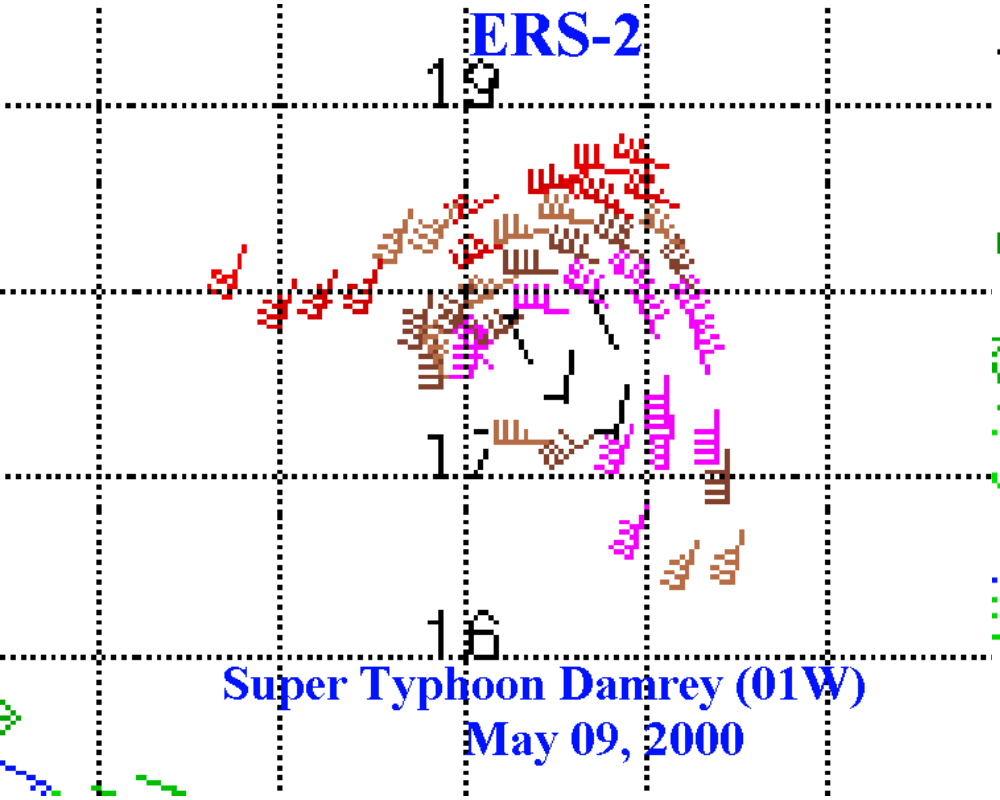
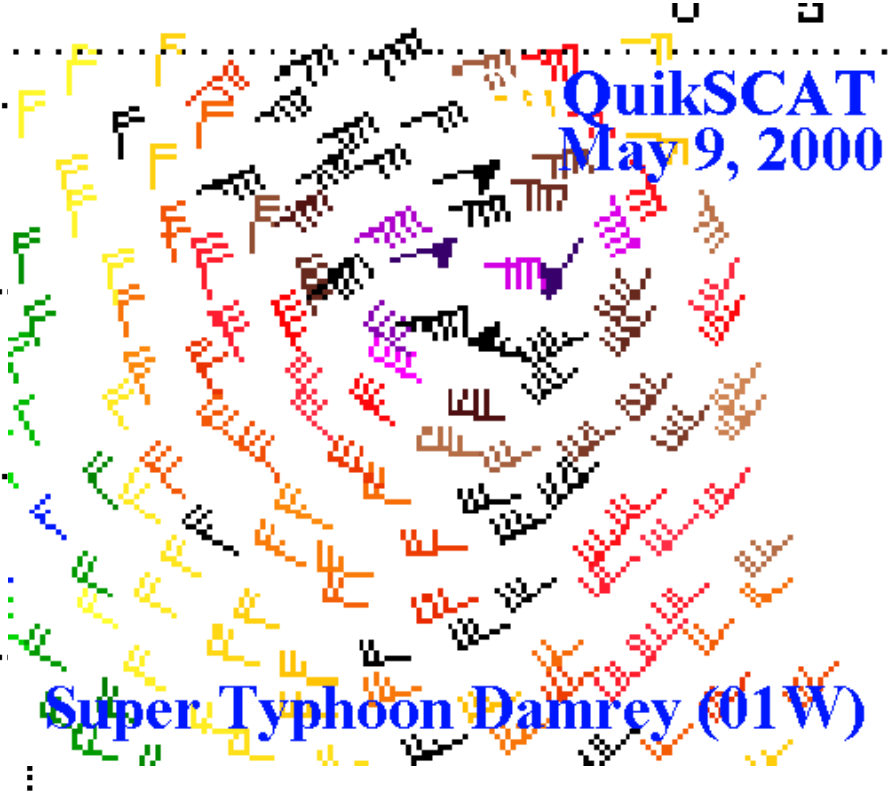
EVALUATION OF ERS-2 AND QUIKSCAT OVER TROPICAL CYCLONES





EVALUATION OF ERS-2 AND QuikSCAT OVER TROPICAL CYCLONES

GOAL: Evaluate the use of the new SeaWinds Scatterometer (QuikSCAT) for Tropical Cyclone analysis.

METHODOLOGY: Comparisons with the older ERS-2 Scatterometer, as well as with Surface Analyses, Aircraft Reccon, and other in situ observations.

INTRODUCTION

- **Comparisons Between ERS-2 and QuikSCAT Scatterometer Sensors**
- **Physics of Scatterometer wind vector retrieval**
- **Examples of “Problem Areas”**
- **Examples of “Good (to spectacular) Areas”**
- **Case Studies:**
  - **Data Base**
  - **Comparison with aircraft reconnaissance**
  - **Life cycles of Tropical Cyclones**
- **Results**
- **Recommendations**
- **Conclusions**

QuikSCAT: Scatterometer Using Antenna Disk

History:

- Follow On to NSCAT
- Precursor to Seawinds

Scanning Geometry:

- conical scan
- 1800 km continuous swath

Orbit:

- sun-synchronous
- ascending node near 6 AM
- 803 km altitude

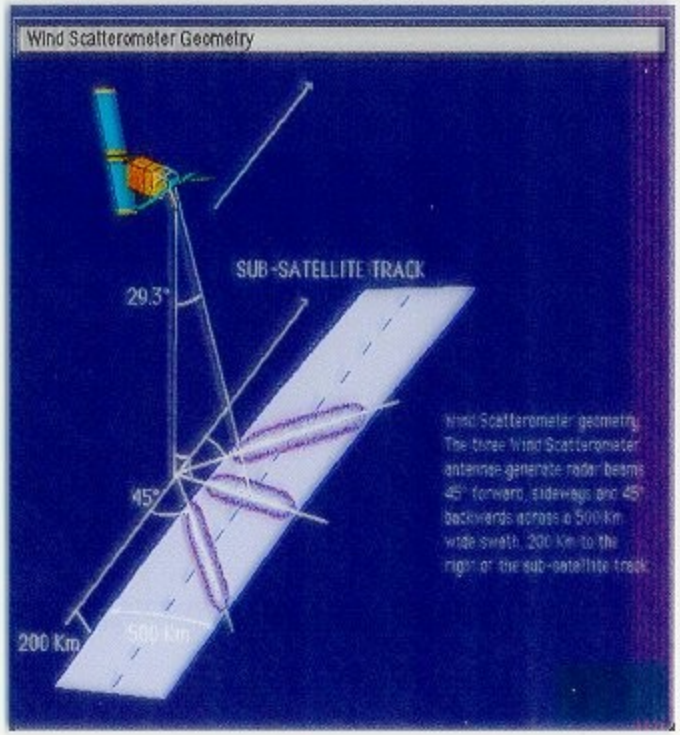
Launch Date: 29 April 99

Courtesy NASA/JPL

ERS-2

SCATTEROMETER

INST (AMI)



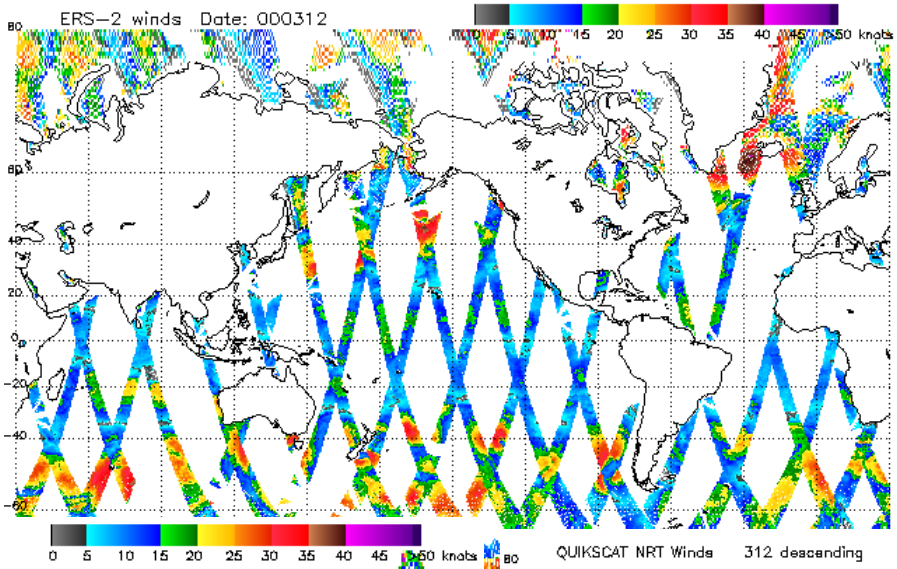
- Active Microwave Radar
- 785 km Altitude (104 minute orbit)
- 500km Swath
- 50 (25) km Resolution
- Wind Accuracy from 6-50kts (1-2m/s rms)
  - –CMOD4 transfer function simulates Buoy Data (8 minute average)
- Wind Direction 15-20 deg rms (requires wind directional algorithm)
- Navigation +- 5 km

AMI - SCATTEROMETER AND SYNTHETIC APERTURE RADAR

RECENT SCATTEROMETERS

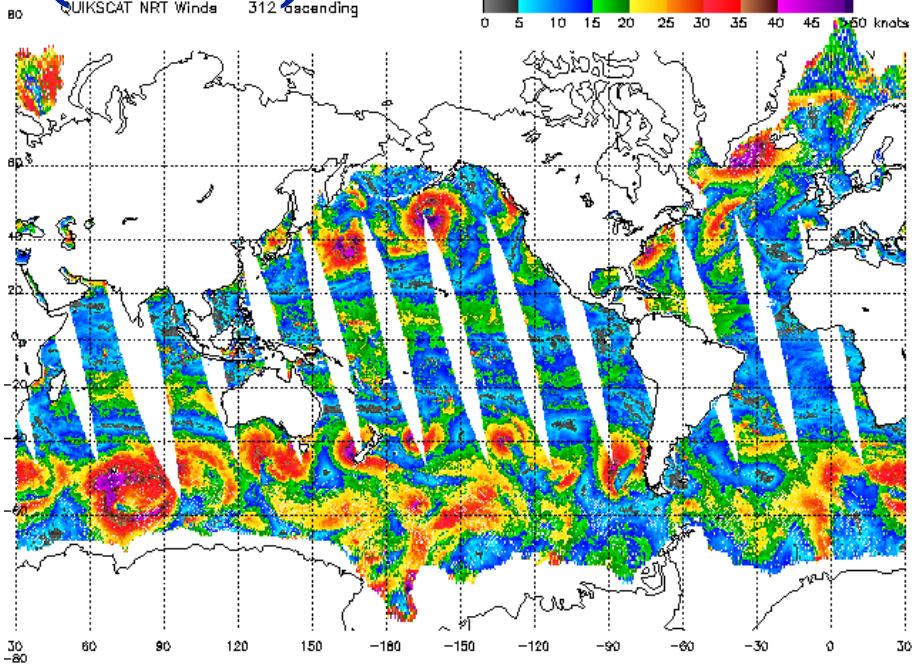
SENSOR/SAT	ERS-2	NSCAT	SEAWINDS (QUIKSCAT)
AGENCY	ESA	JPL	JPL
LAUNCH	APR 95	AUG 96	JUN 99
SWATH (KM)	500	2x600	1800
CENTER GAP (KM)	225	320	0
ANT CIRCU	3	6	
NAVGTN (km) Abs	25	25	25
Rel	10	10	10
RESOLU(KM)	50	50/25	25
SPEED (M/S)/	3-20	3-30	3-30+
ACCURACY	2 OR 10%	2 OR 10%	2 OR 10%
DIR (Deg_rms)	15-20	15-20	15-20

SCATTEROMER DAILY COVERAGE

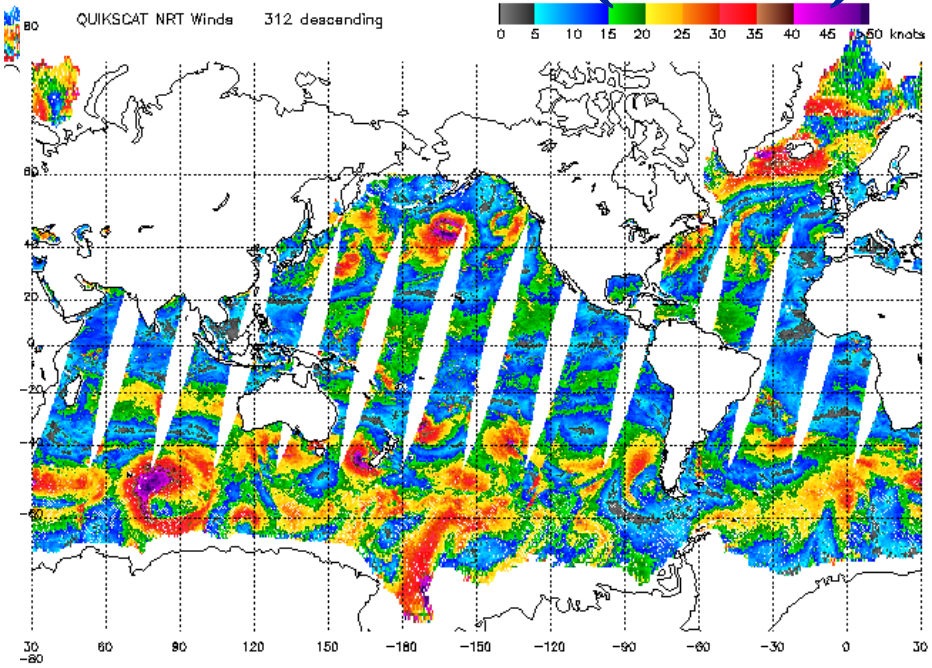


ERS-2

QUIKSCAT (ASCN)



QUIKSCAT (DSCN)



PHYSICS OF

MICROWAVE SCATTEROMETR

AND WIND RETRIEVAL

OBTAINING WIND SPEED AND DIRECTION FROM THE OCEAN SURFACE USE SCATTEROMETRY

(Theory)

- **The scatterometer sensor is an active microwave imager that sends and receives microwave energy off the ocean surface**
- **Microwave energy is sensitive to the "roughness" of the ocean surface that is generated by the surface wind field. This roughness is manifested in small capillary size waves (or ripples) known as Brag Waves**
- **Due to the assymetric nature of these Brag Waves in relationship to the wind speed and direction, it is possible to derive a wind field from an inversion technique by viewing the same area of ocean from several angles**

WIND RETRIEVAL and AMBIGUITY SOLUTIONS

- **ERS-2 uses CMOD4 wind retrieval method to estimate wind speeds from Normalized Radar Cross-Section (Sigma-0) of backscatter microwave radiation over the oceans**
  - **3 Antenna at 3 different angles (can not see at nadir)**
  - **ECMWF used as initialization in ambiguity (direction) process**
- **QuikSCAT uses NSCAT2 (QuikSCAT1) wind retrieval method**
  - **Circular Scan at 2 zenith angles**
  - **Fore and Aft views allow up to 4 solutions**
  - **Solutions are "Ranked" based on Most Likelihood Estimator (MLE)**
  - **AVN used as initialization in ambiguity (direction) process**
  - **A multi-process "Buddy System" using a medium filter evaluates neighboring Wind Vector Cells (WVC) to make the final "Selection"**
  - **Each WVC is assigned a Rain Flag based on a likelihood determination**

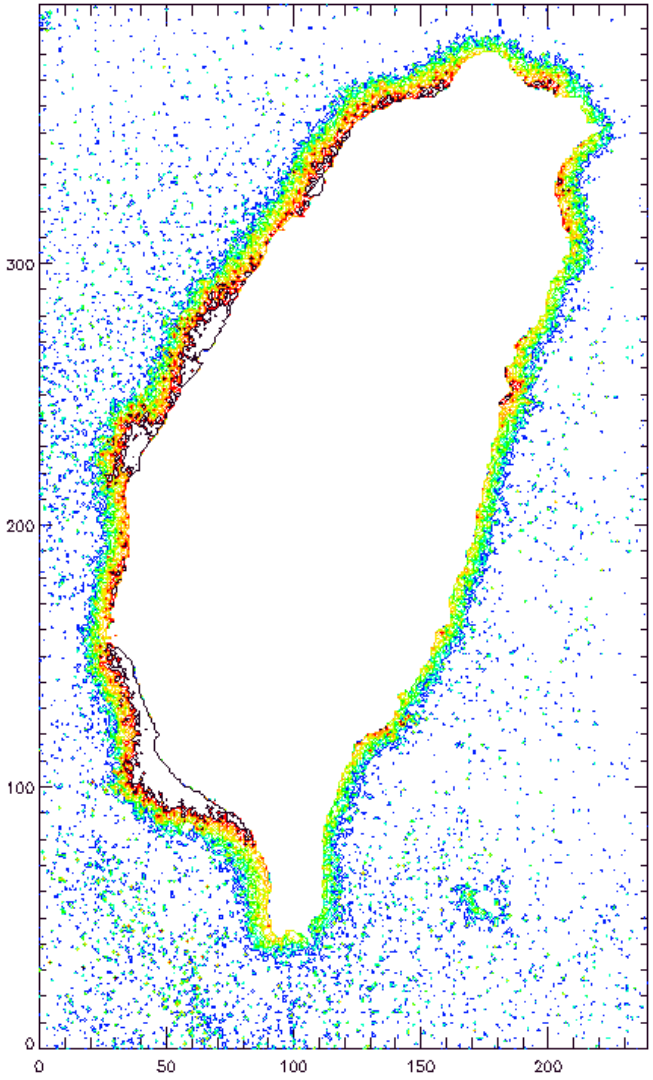
QuikSCAT: Resolution and Coastal Measurements

- ~ 35 km characteristic dimension

- Land/ice contamination depends
  on environmental parameters
  - Wind
  - Non-ocean cross-section
  - Radar side lobes

- 30 km land mask is conservative
  - 15-20 km possible for most coastal topographies

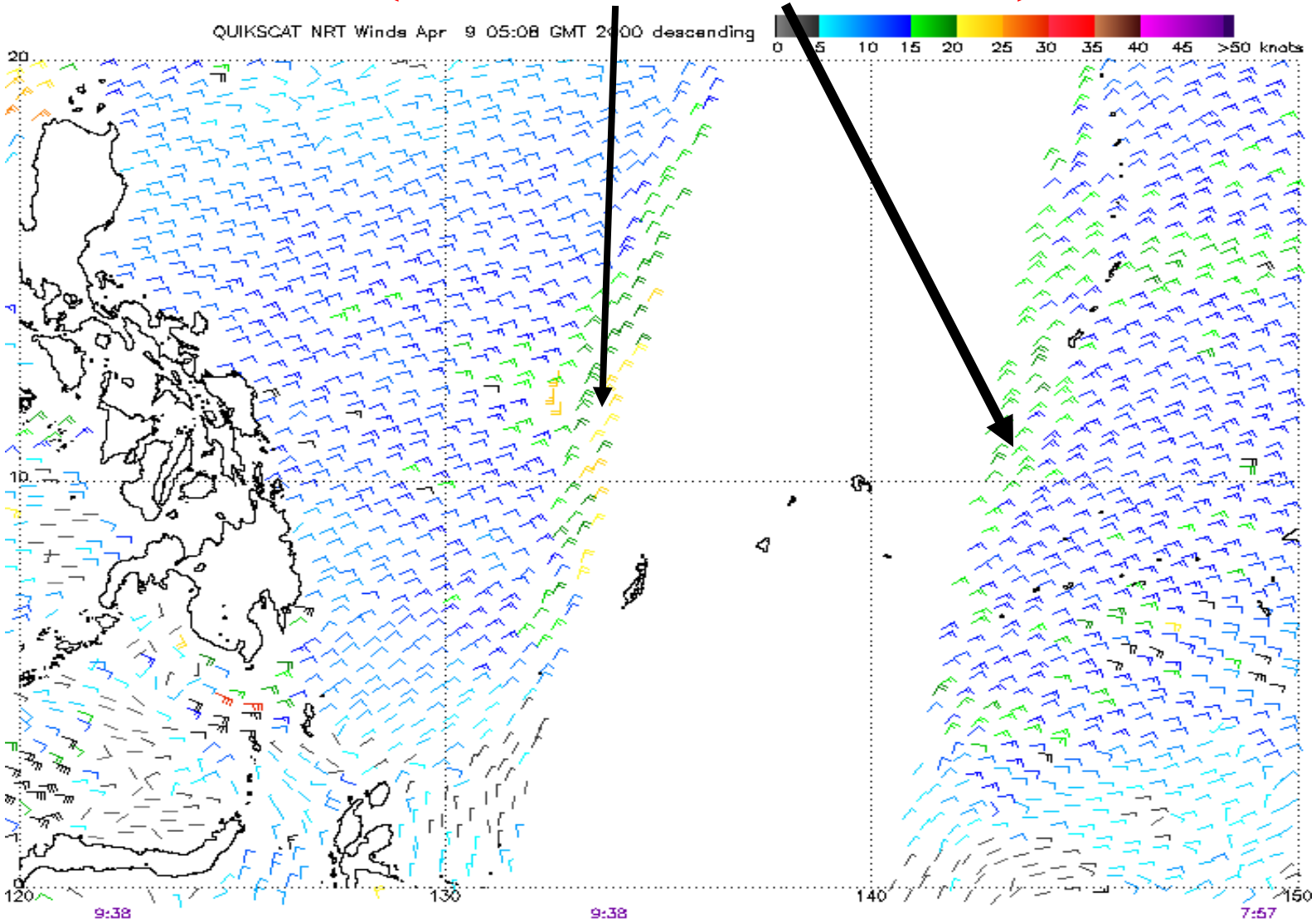
- 18 km may be achievable for slice processing on 12.5 km grid

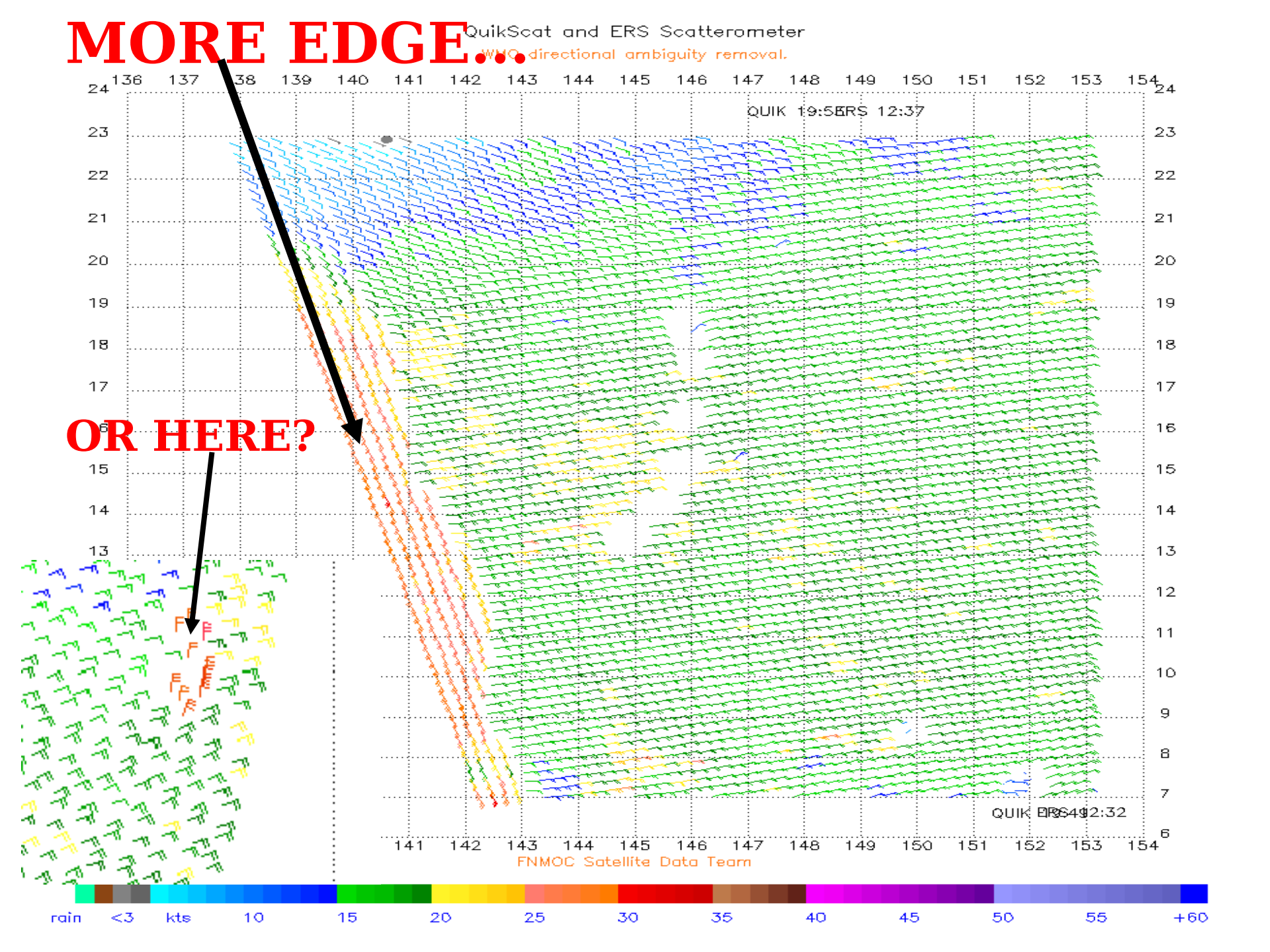


QUIKSCAT PROBLEM AREAS (Usually in Low Skill Areas)

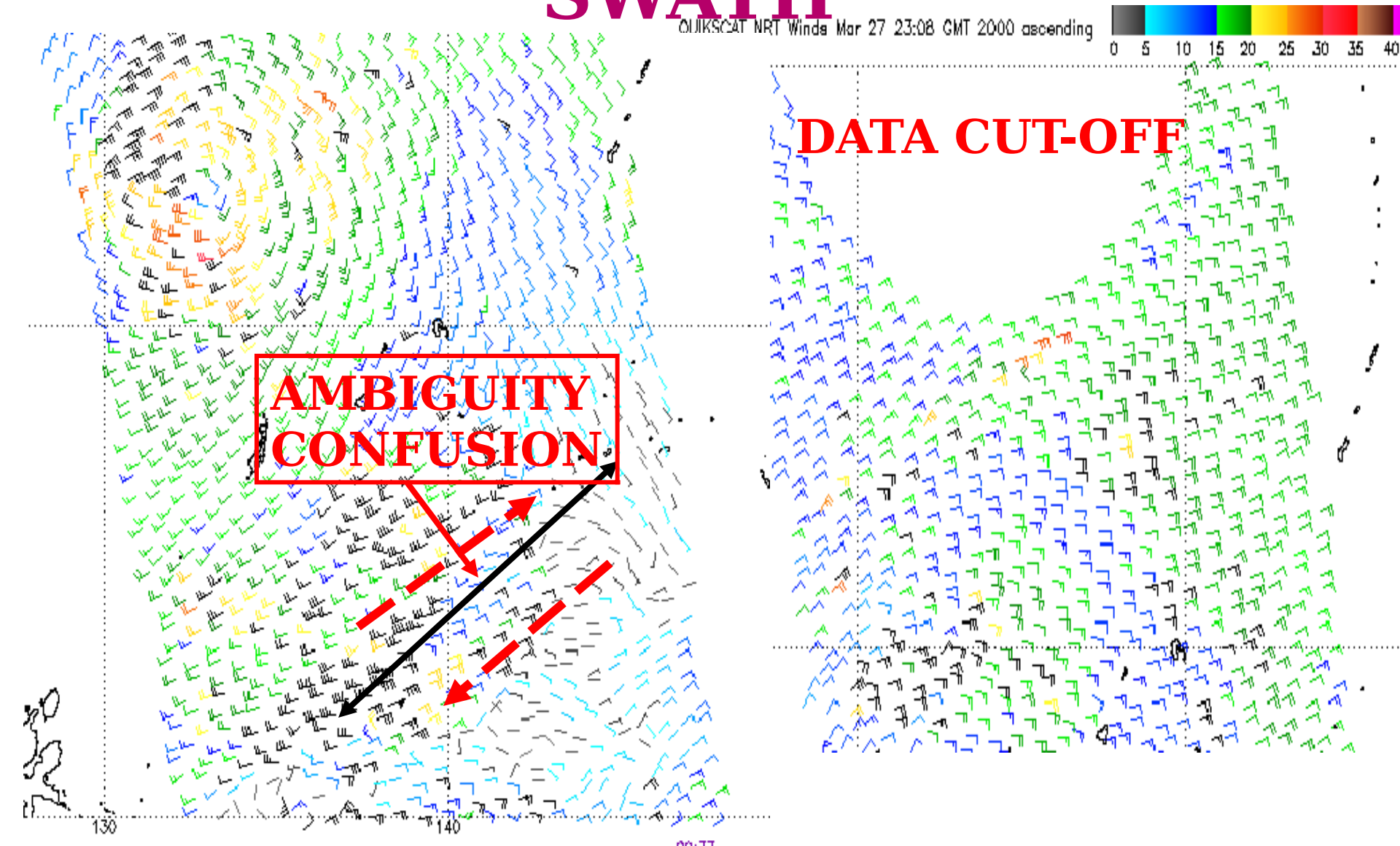
- **EDGE OF SWATH (~ 7 wvc) and ALONG SUB-TRACK (3-4 wvc)**
- **SENSITIVITY TO HEAVY RAIN**
  - **Surface Roughness (Especially in Low Wind areas!)**
  - **Rain Scattering and Absorption**
- **SENSITIVITY TO ERRORS IN NWP MODEL IN LOW SKILL LOCATIONS**
- **“PRACTICAL” WIND REGIME BETWEEN 10 AND 30 m/s**
  - **Problems in both LIGHT winds and very HEAVY winds**
- **RESOLUTION (25 km) OF FOOTPRINT WILL LIMIT WIND RETRIEVAL IN TIGHT GRADIENT REGIONS (ie. near center of TC)**

EDGE PROBLEMS (EITHER SIDE)



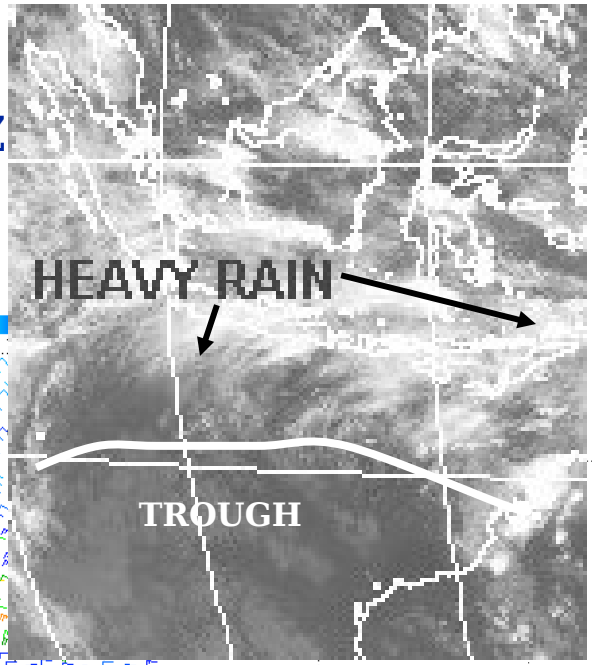

MORE EDGE...
OR HERE?
QuikScat and ERS Scatterometer
MLM directional ambiguity removal.
QUIK 19:58ERS 12:37
QUIK ERS 12:32
FNMOC Satellite Data Team
rain
<3
kts
10
15
20
25
30
35
40
45
50
55
+60

QUIKSCAT ERRORS ACROSS THE SWATH

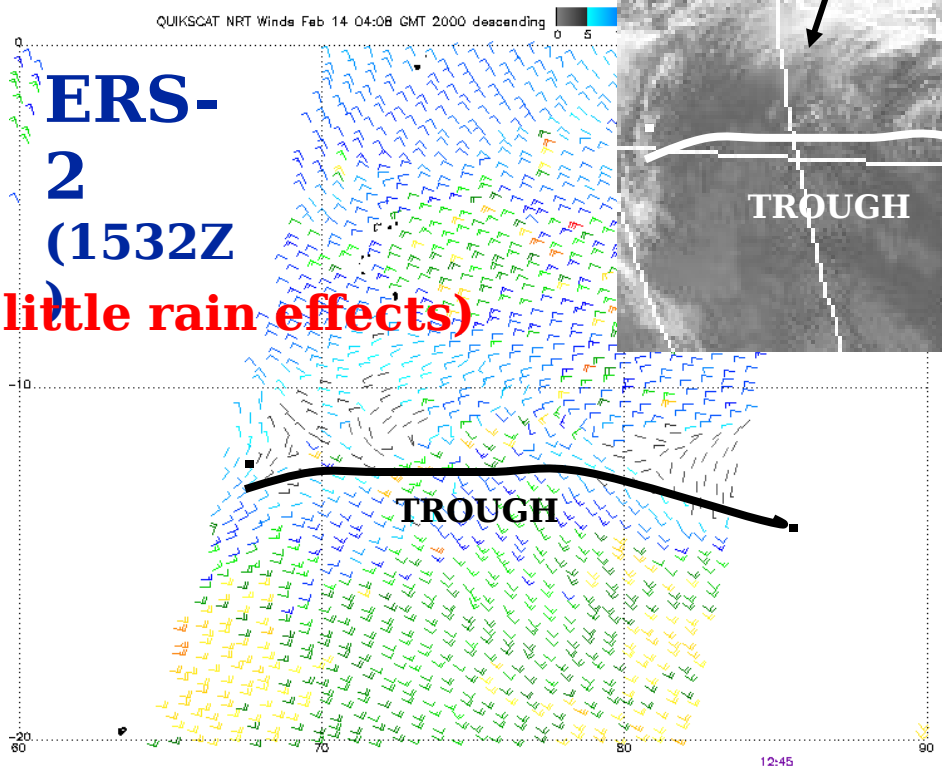


QUIKSCAT
RAIN CONTAMINATION

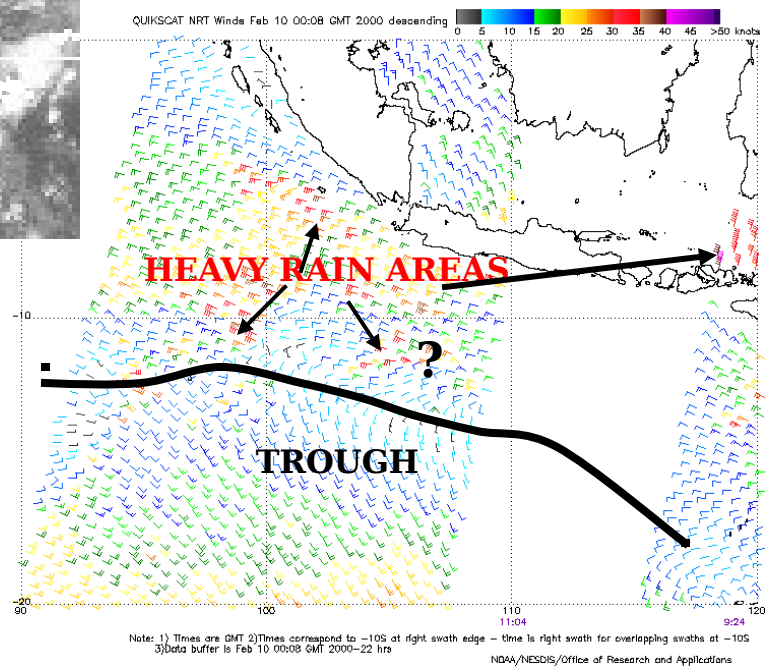
IR IMAGERY
12 Feb 1230Z



ERS-2
(1532Z)
(little rain effects)

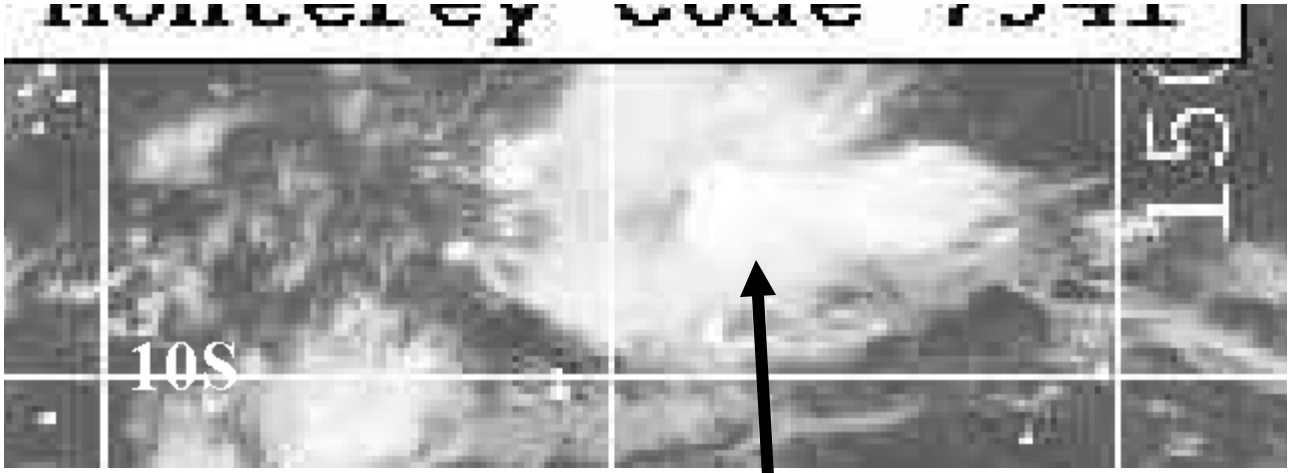


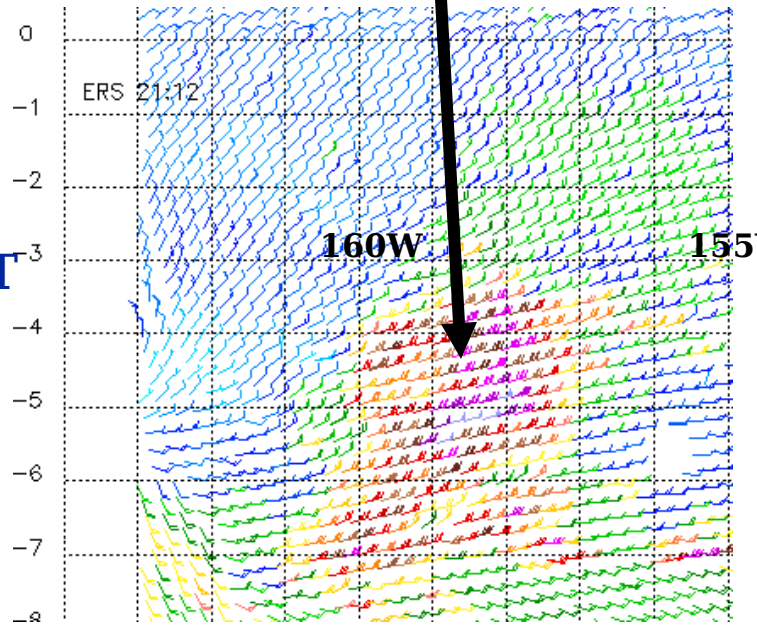
QUIKSCAT
(1038Z)



QUIKSCAT
RAIN EFFECTS

12 MAY 2100Z

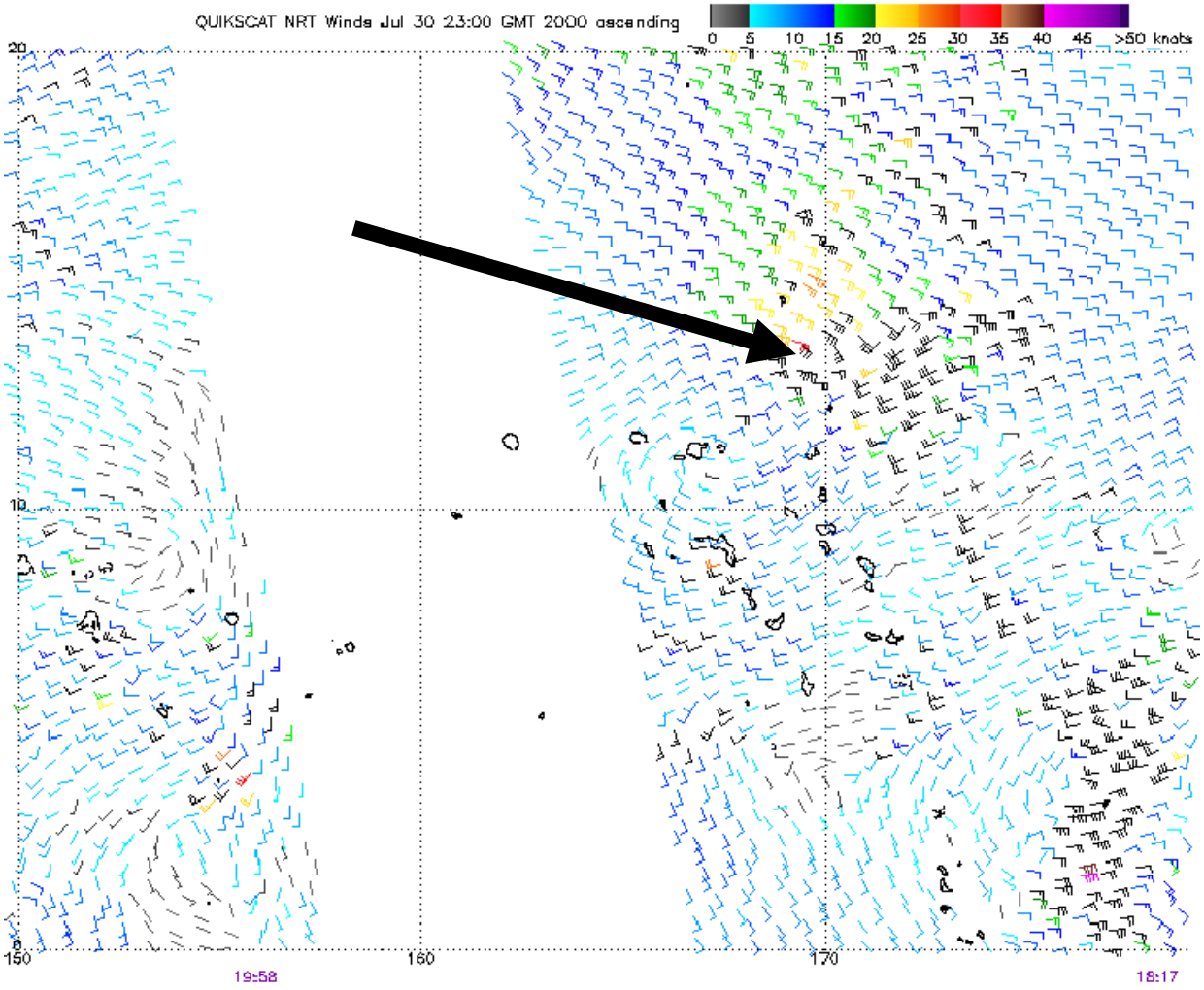




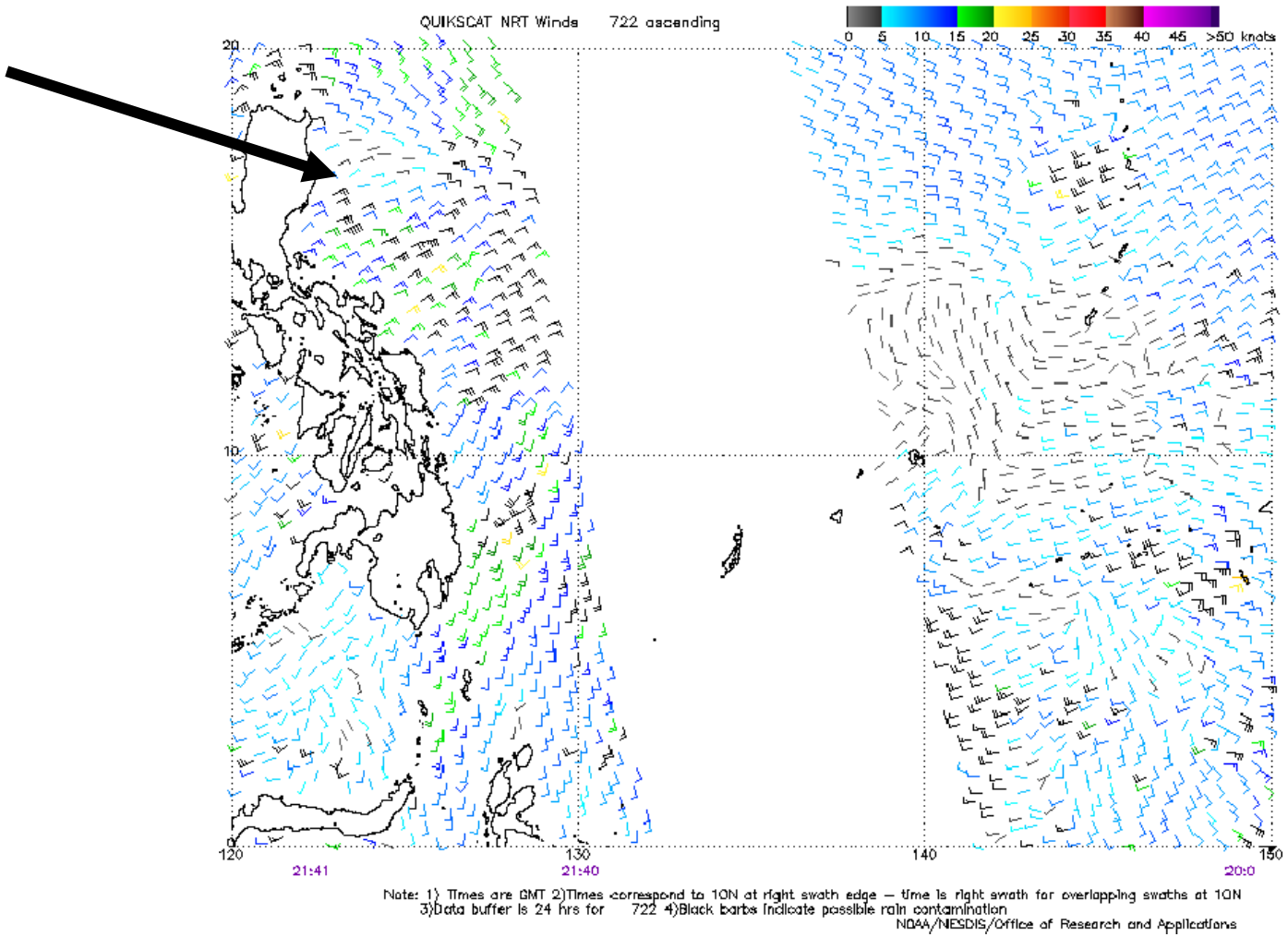
QUIKSCAT
12/1616Z

(LIGHT WIND AREA)
0 - 10 m/s

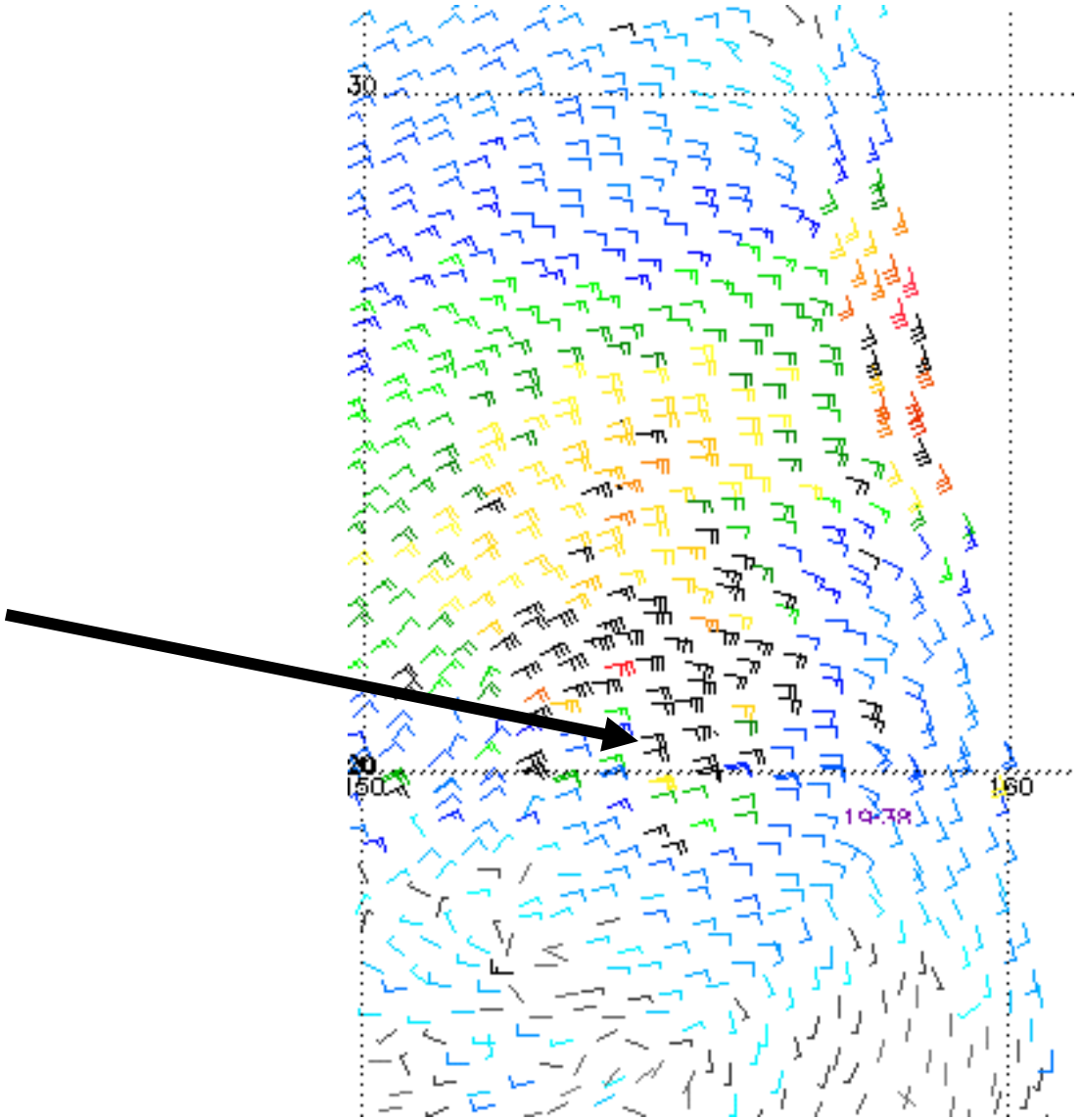
QUIKSCAT
RECENT RAIN EFFECTS



QUIKSCAT
RECENT RAIN EFFECTS
WHERE DID TD 10W GO?

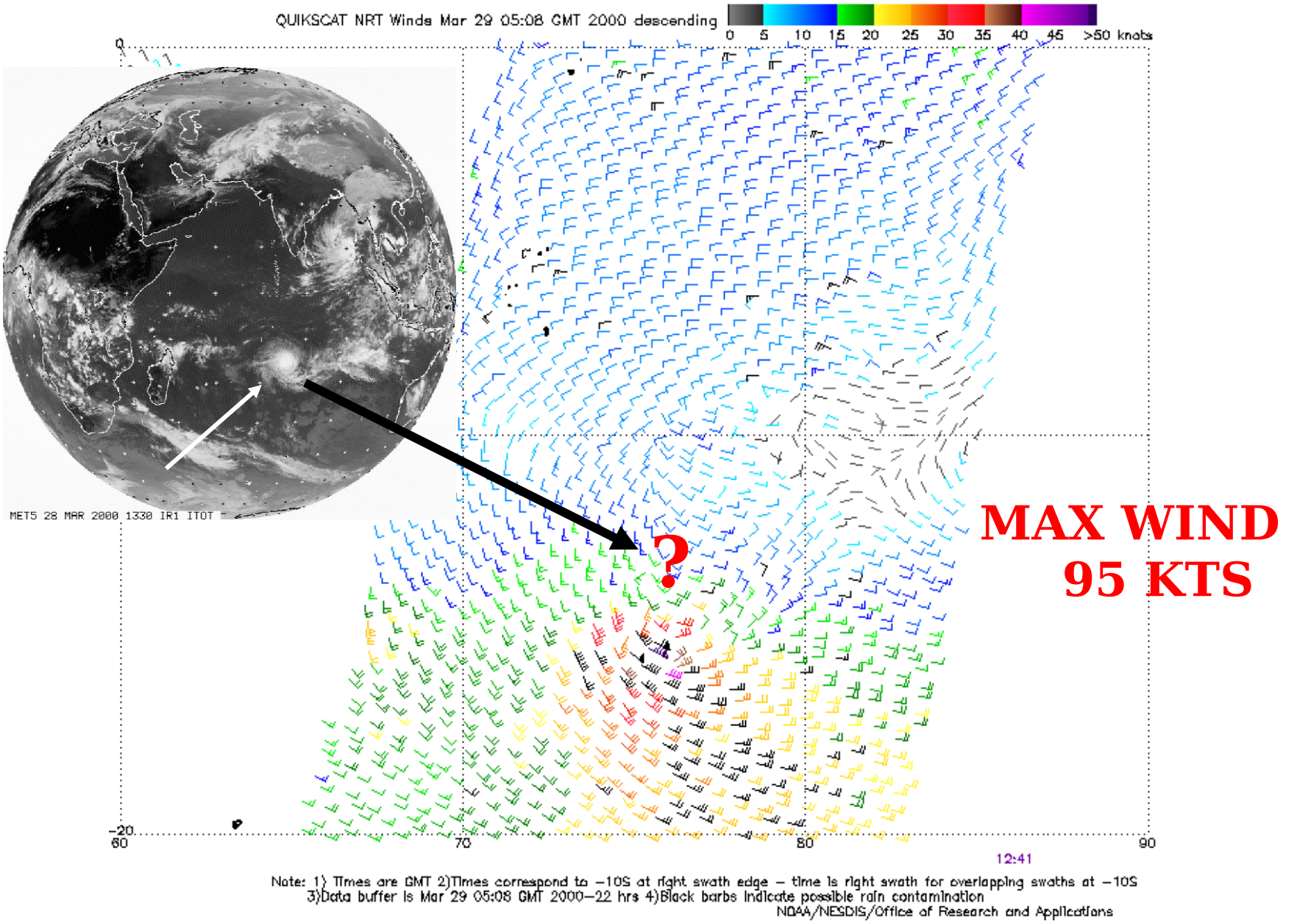


HOW ABOUT TYPHOON JELAWAT 13W??



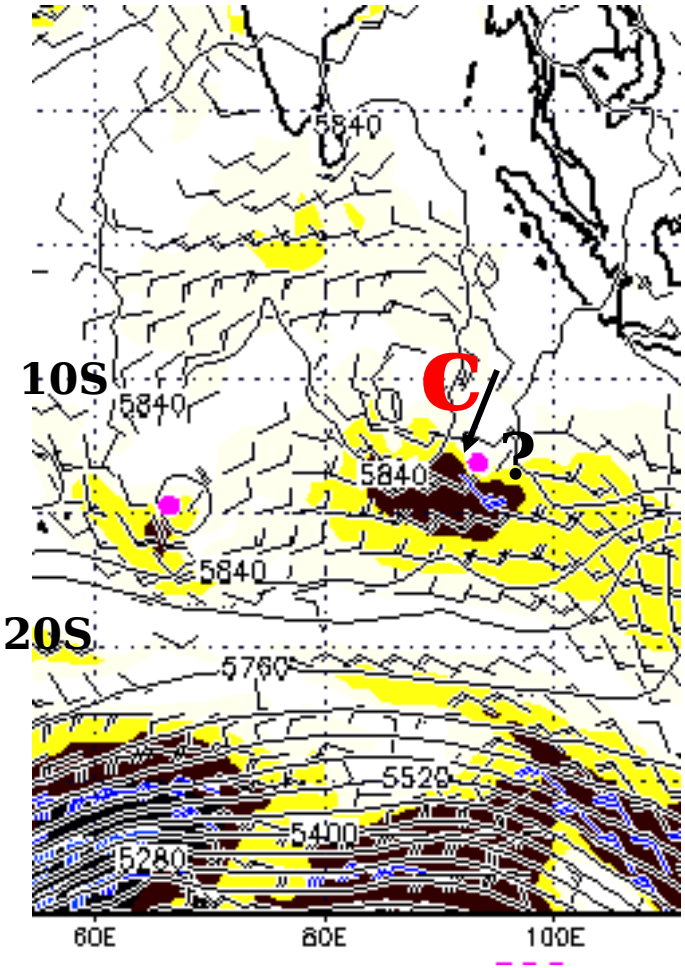
WHERE'S IS TROPICAL CYCLONE 21S (HUDAH)?

Model Dependency?

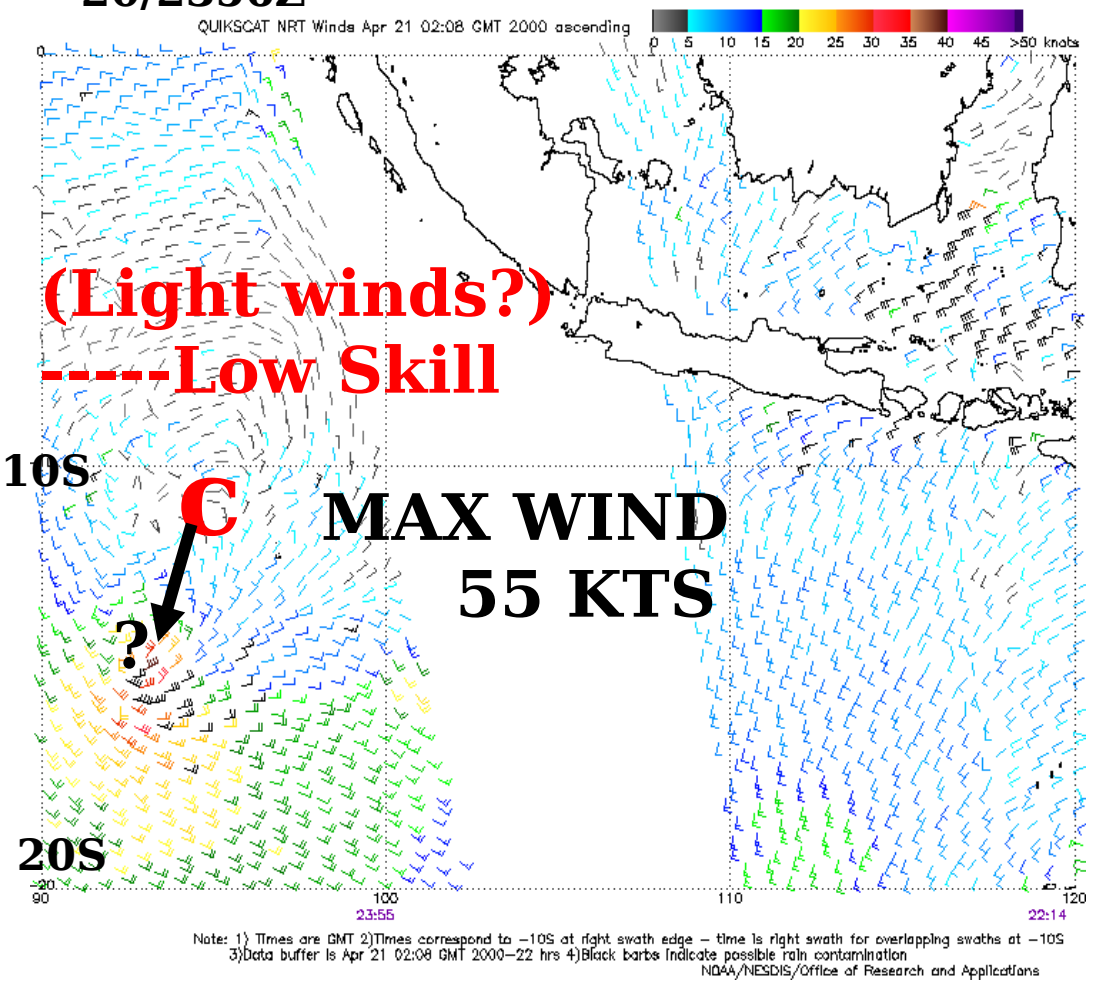


QUIKSCAT
TC 24S (Paul), April 20, 2000
MODEL INITIALIZATION?

AVN 19/12Z tau 24

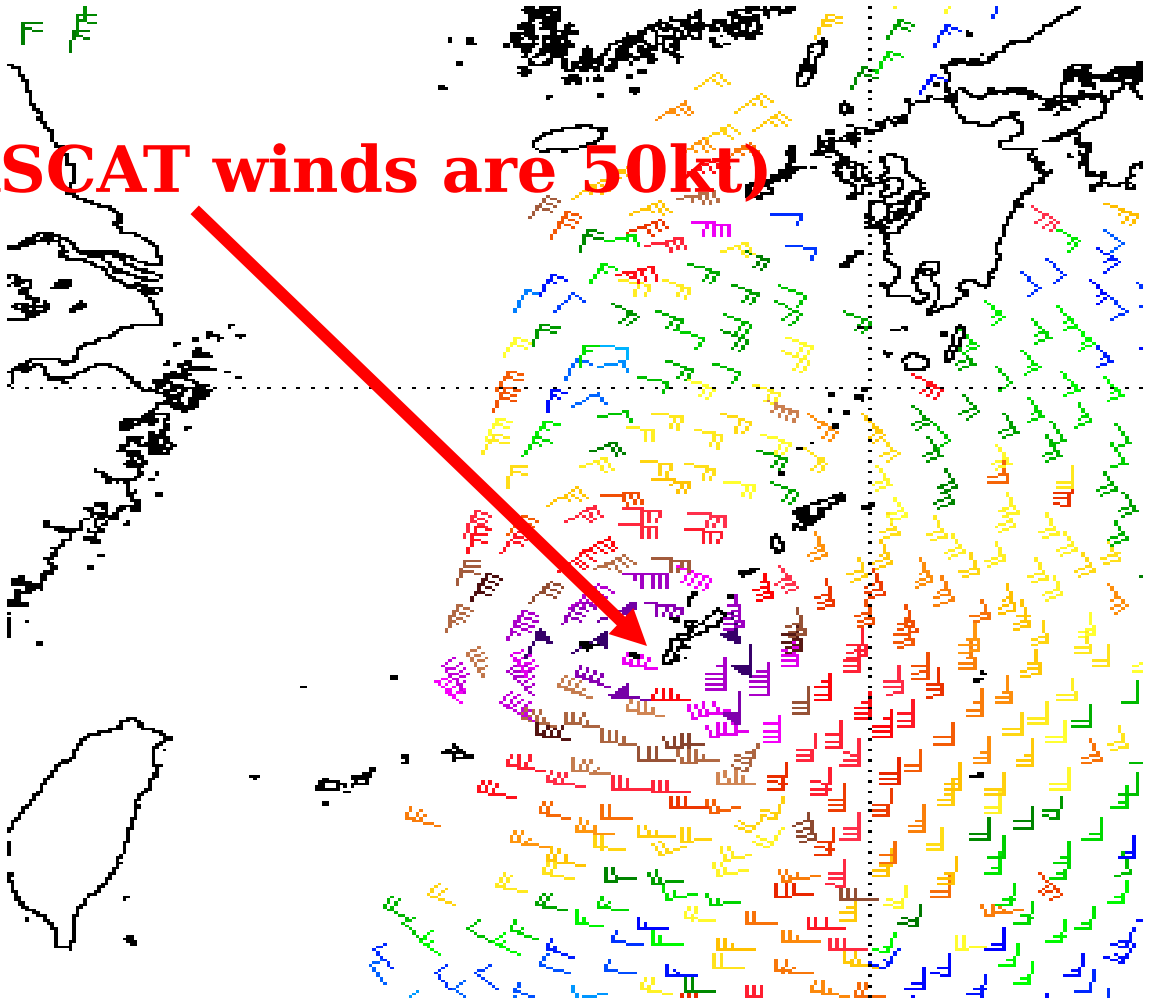


20/2356Z



SUPER TYPHOON BART (24W)
Best Track Intensity is 140 kt

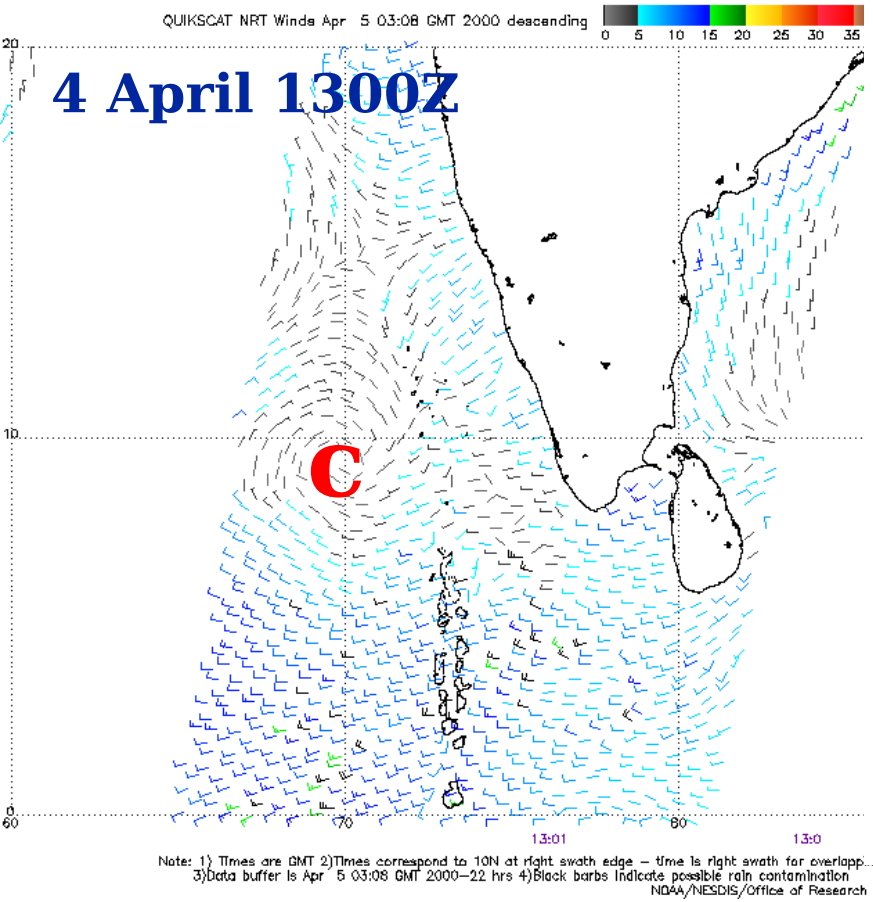
LIMITATION ON CENTRAL MAXIMUM WINDS

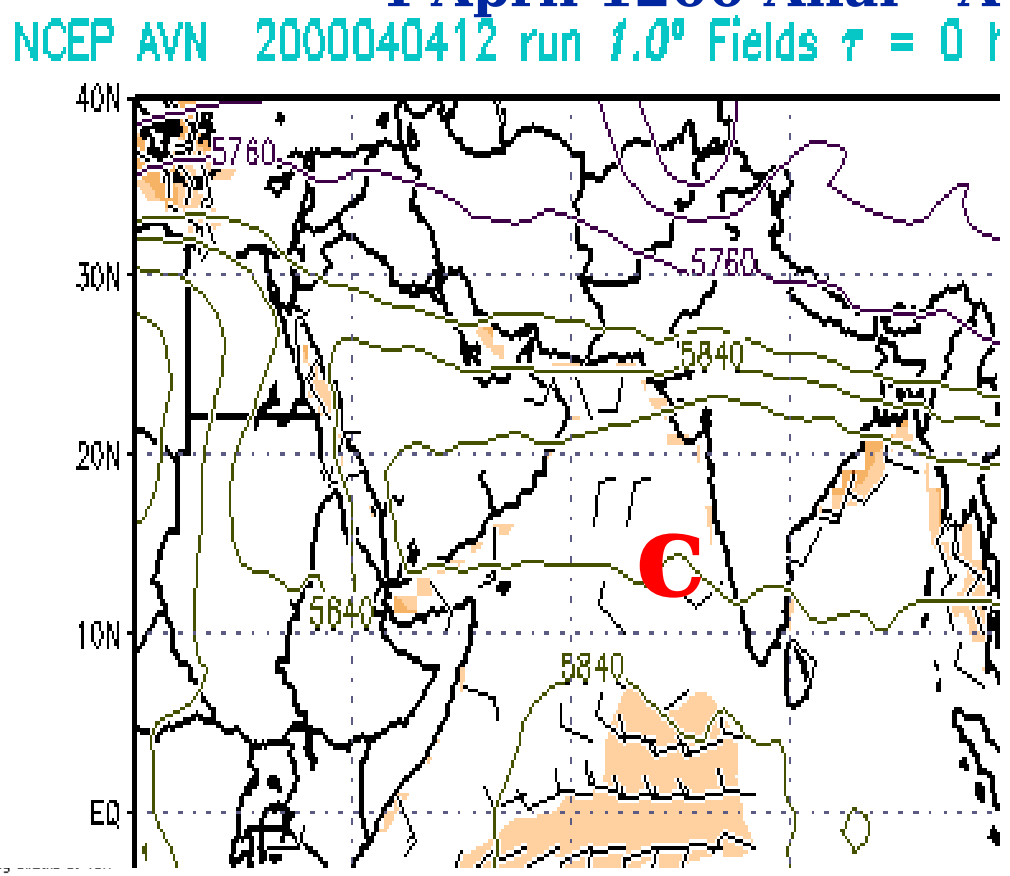


QUIKSCAT SYNOPTIC-SCALE EVALUATION

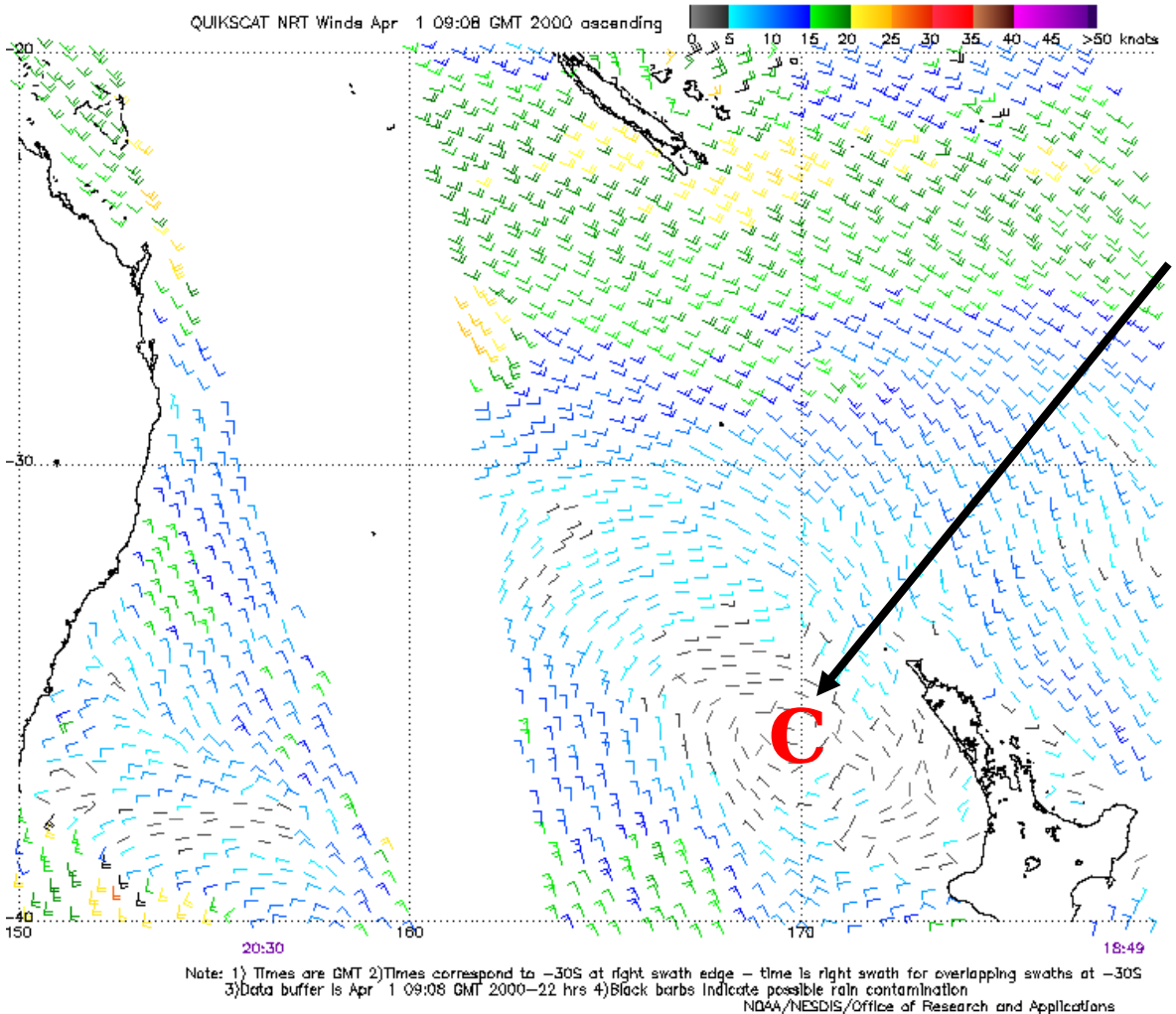
(VERY PROMISING…)

QUIKSCAT
ARABIAN SEA CIRCULATION
WINDS (0 - 5 m/s)--Nice Job!





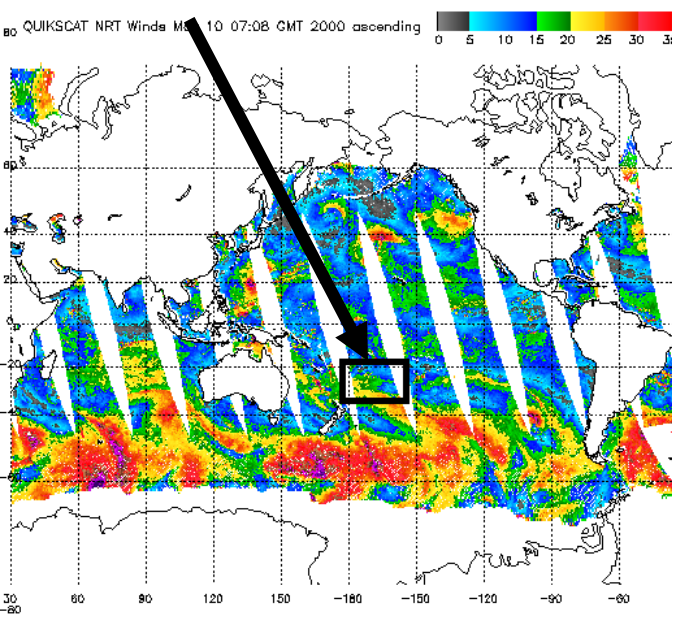
QUIKSCAT
TASMAN SEA CIRCULATION
WINDS (0 - 5 m/s)--Nice Job!

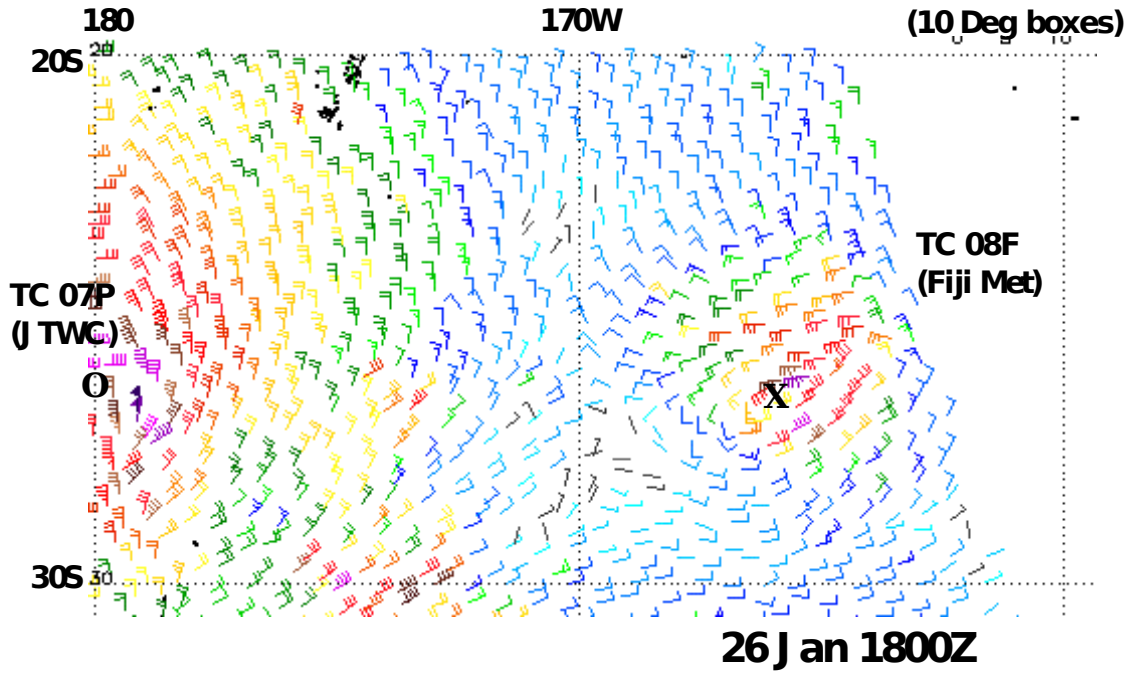


31 Mar 200

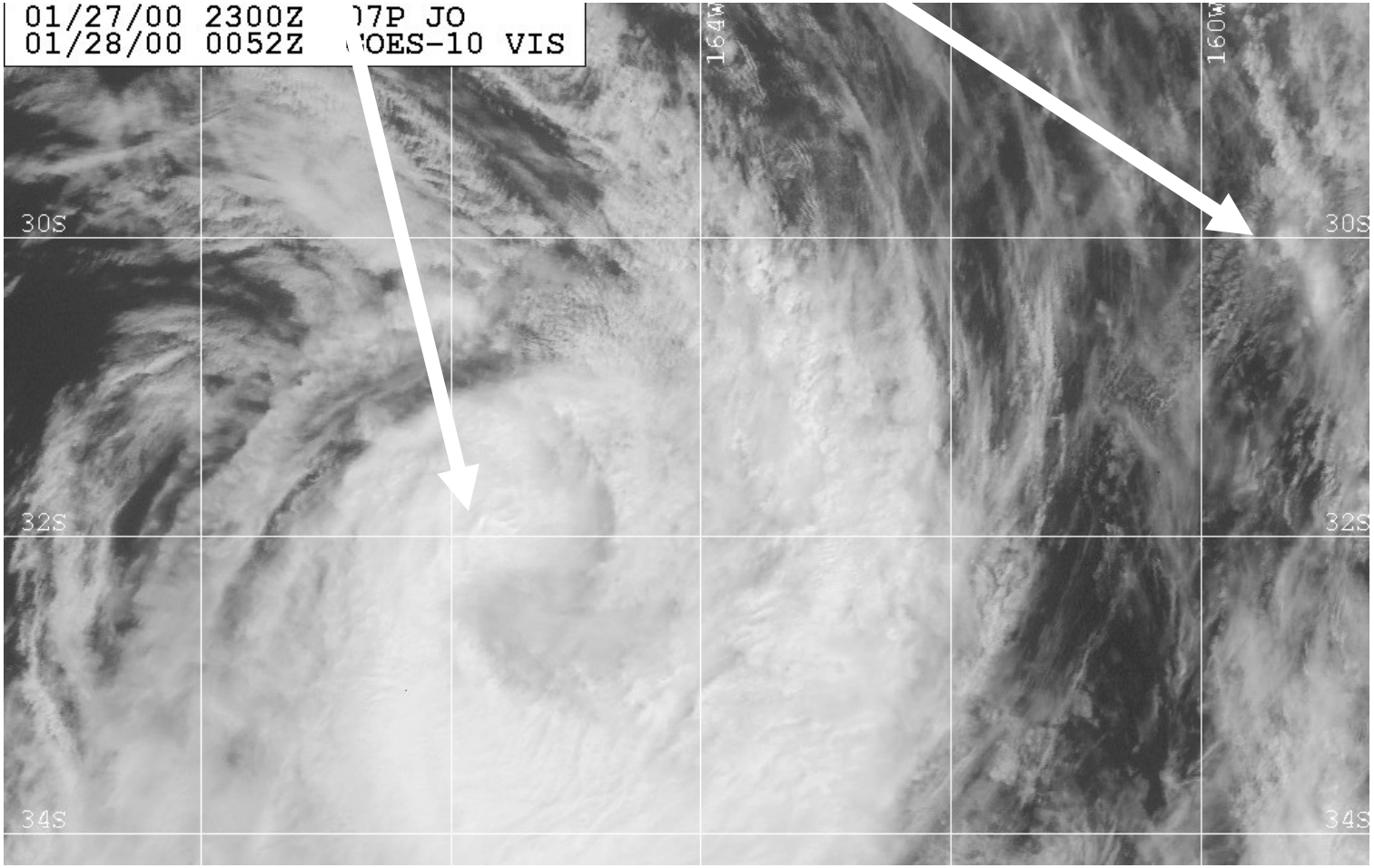
QUIKSCAT
TROPICAL CYCLONE
INTERACTION
TC 07P (JO) and TC 08F

DATA POOR REGION





QuikSCAT INTERACTION TC07P (JO) AND TC08F (UNNAMED) (28 JAN 0000Z)



VALIDATION OF SCATTEROMETER WIND VECTOR DATA

- Comparison to ship observations (ERS-2)
- Comparison to synoptic observations and aircraft reconnaissance (QuikSCAT)
- Life cycles of Tropical Cyclones

ERS EVALUATION

Wind intensity underestimated for winds over 15 m/s

SCATTEROMETER VS SHIP DATA

Special "control" ship **All ships**

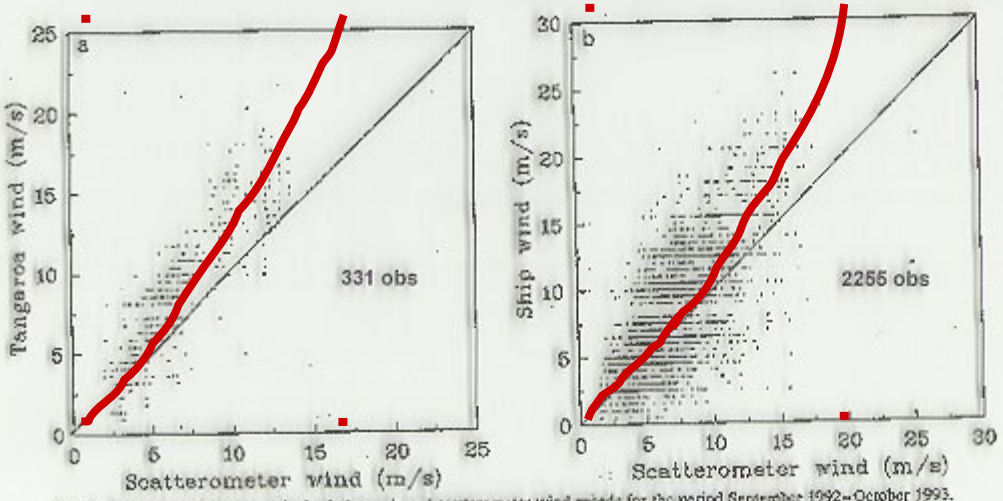


Fig. 2. Comparisons between ships' wind speeds and scatterometer wind speeds for the period September 1992–October 1993. (a) Winds for the *Tangaroa* are used and a reduction factor of 0.9 has been applied, and (b) all other ships are used.

(Laing and Brensturm, 1996. Weather and Forecasting)

(also, Kent et al. (1997))

"Suggested Solution"

"Scatterometer data are more accurate than any other operationally available wind dataset." (Stoffelen and Anderson, 1994: 2nd ERS Symposium)

****SCATT WINDS TEND TO UNDERESTIMATE WINDS OVER 30 KNOTS****

ERS-2 and QuikSCAT

“Suggested”WIND SPEED CONVERSION

** Based on Conversion of simulated 8’ Buoy wind to 1’ wind at 10 meters AND (For ERS-2, only) Ship Comparisons showing underestimation of winds over 30kts (Ref: Laing and E. Brenstrum, 1996) AND Current Study.

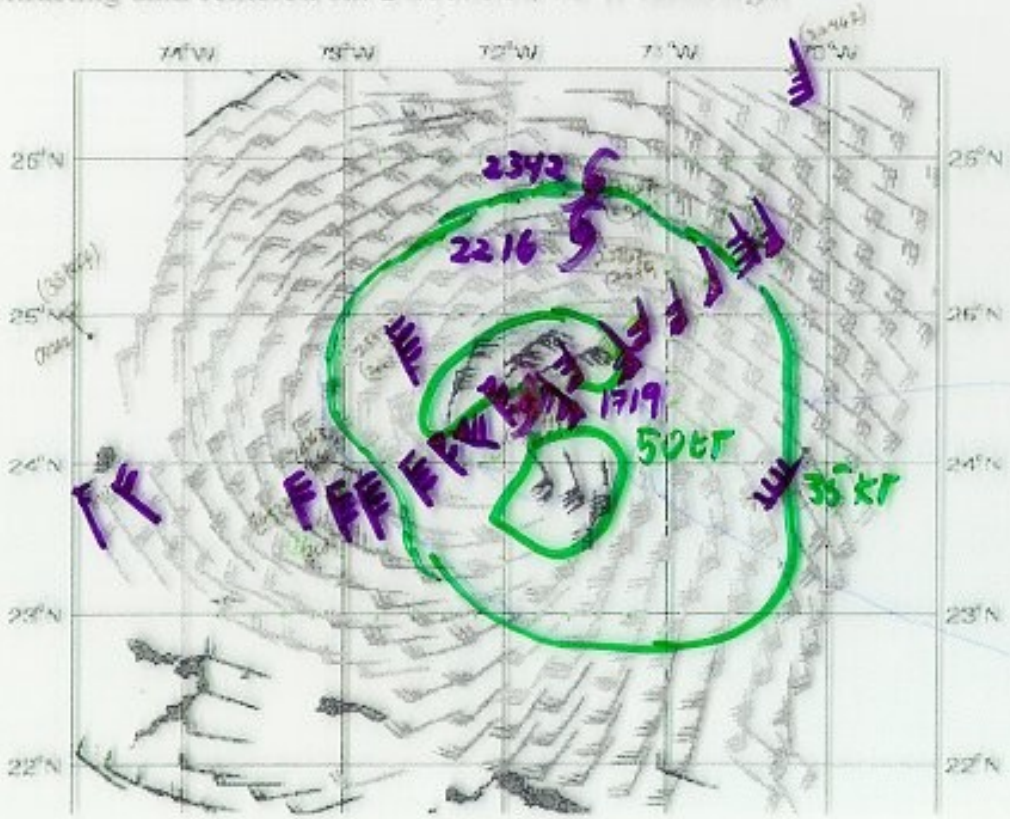
SCAT VECTORS (kt) **	ESTIMATED 1’ WINDS (kt)	
	QuikSCAT	ERS-2
10	10	10
15	15	15
20	20	20
25	30 ??	30
30	30 ???	35
35		

ERS-2 SCATTEROMETER

HURRICANE HORTENSE
SCATT VS AIRCRAFT
SEPT 1996

12/1517Z

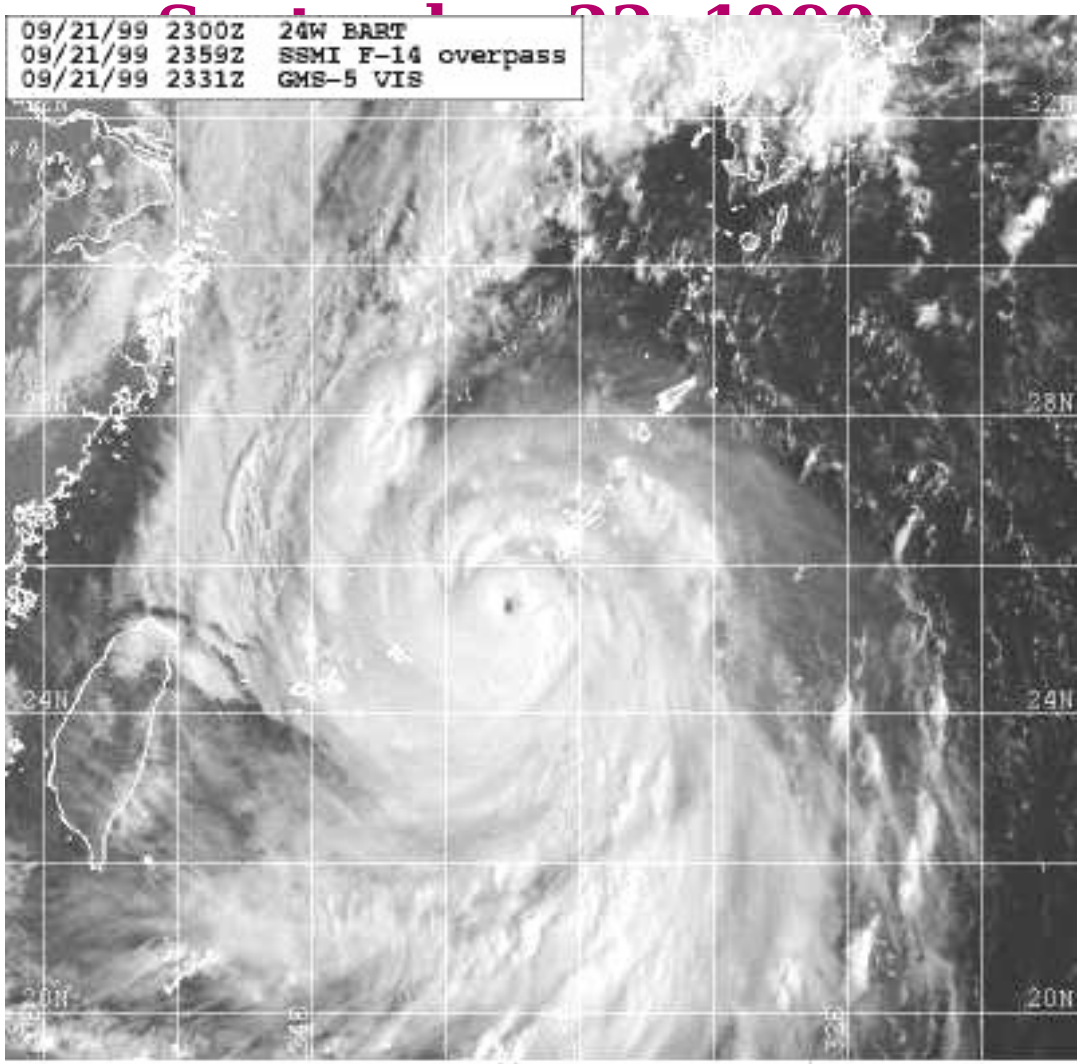
Date of Most Recent Observation: Thu Sep 12 15:17:01 1996 (ZULU)
Extracting data centered on: 24.1196 N, 72 W dataext.gif



(700MB)

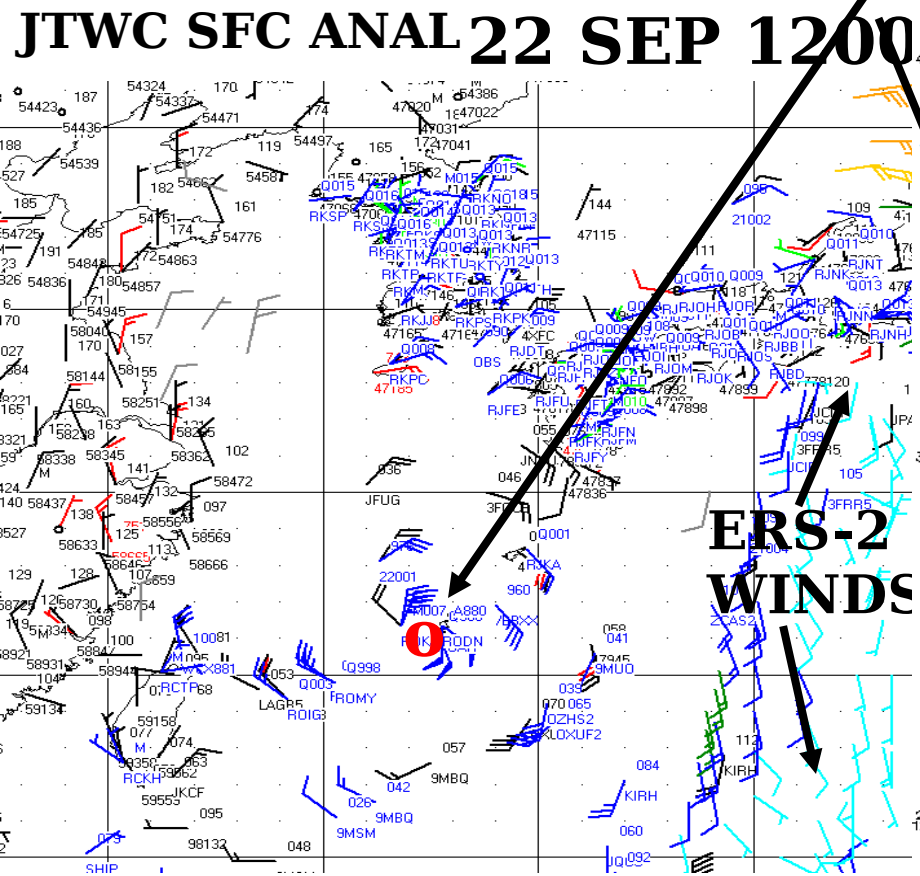
Note: Reduction to sfc from 700 is approx 0.7 - 0

SUPER TYPHOON BART (24W)

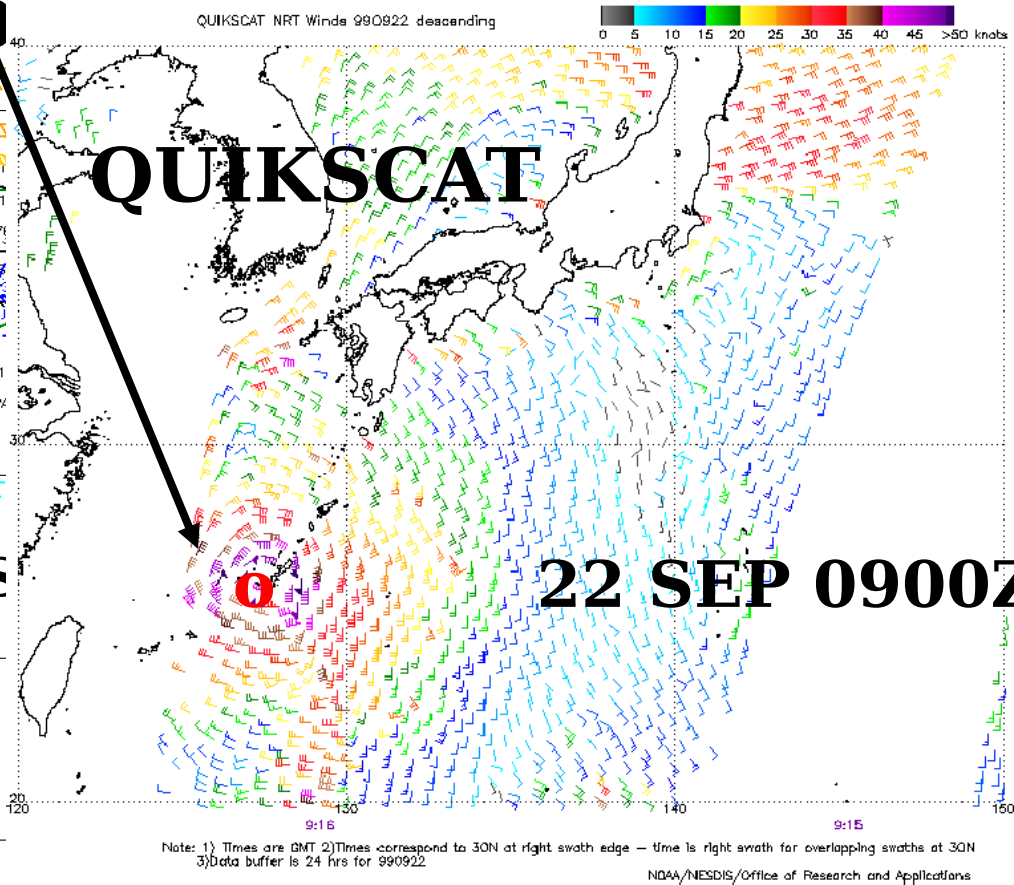


QUIKSCAT COMPARED TO SURFACE ANALYSIS

STY BART (24W)

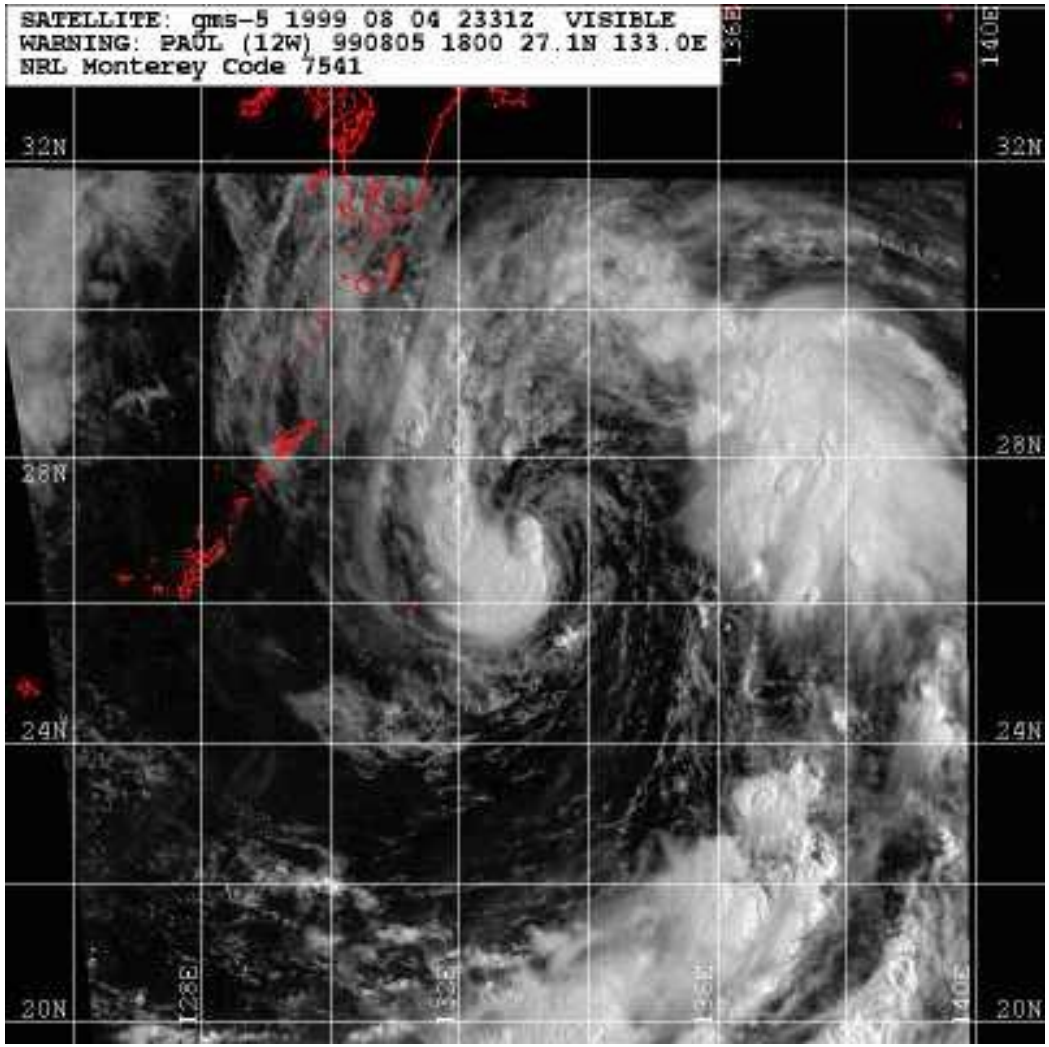


ERS-2 WINDS



TS PAUL (12W)

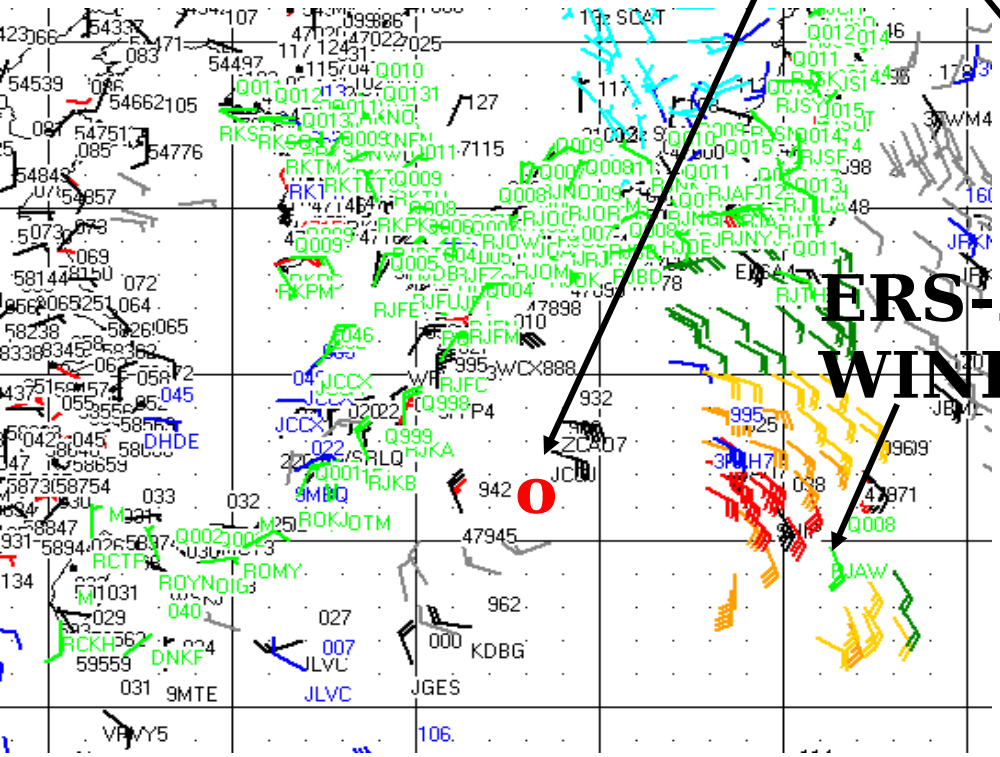
August 5, 1999



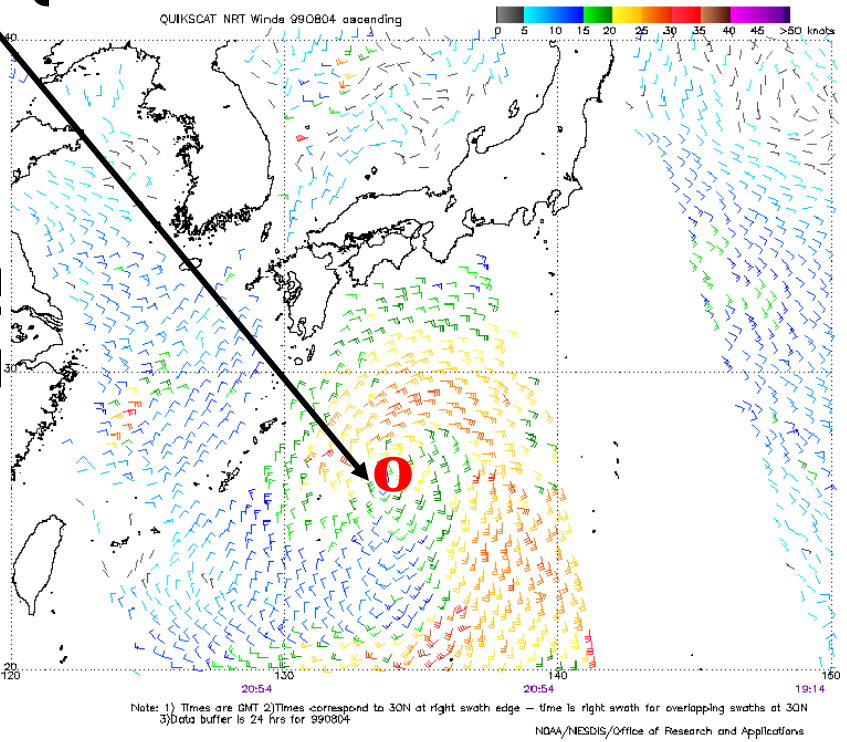
QUIKSCAT COMPARED TO SURFACE ANALYSIS

Tropical Storm Paul (12W)

JTWC SFC ANAL **5 AUG 0000Z** **QUIKSCAT** **04 AUG 2100Z**



ERS-2 WIND



RESULTS

- **Coverage is Excellent, virtually catching entire life cycles of Tropical Cyclones**
- **Although rain contamination is evident in light wind (low skill) regions, it does not seem to deter from evaluation in higher wind (higher skill) regions --up to “some” QuikSCAT limit**
- **Wind direction often good even in rain areas**
- **Wind direction not as reliable in very high winds (excess of 25 m/s) and in low winds *when* model initialization is poor**
- **Initial evaluations shows excellent agreement with both synoptic data and aircraft reports**
- **Winds speeds seem reasonable even in excess of 60kts (under estimation not as evident as with ERS-2)**

RECOMMENDATIONS

- **Trust the scatterometer data like any other piece of data: if it makes sense USE IT**
- **Ambiguity solutions often require a 180^{o} flip of wind direction --especially for ERS-2 and in low skill regions for QuikSCAT**
- **Be aware of typical Low Skill areas, especially in light winds, in rain areas, and along edge of swath (and down the subtrack)**
- **Consistency from one pass to the other (and with the other sensor) adds credence to the data**
- **Know the times of the upcoming passes!**

CONCLUSIONS

USE OF ALL SCATTEROMETER DATA CAN DRAMATICALLY INCREASE THE KNOWLEDGE DATA BASE TO THE TC WARNING SYSTEM

- ***GENESIS*****
- ***POSITION***
- ***WIND RADII***
- ***"MIN"- MAXIMUM INTENSITY***

**** With QuikSCAT coverage this bullet changes from *Last* to *First***